OCU-HEP 2002-01

AFM pictures of the surfaces of glass RPC electrodes damaged by water vapor contamination

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Abstract

We present surface pictures of the damaged electrodes from the Glass Resistive Plate Chambers (GRPCs) taken by an Atomic Force Microscope (AFM). For the test, a set of chambers were operated with freon mixed gas (damaged) and freonless gas (not damaged), contaminated with 1000 $\sim$ 2000 ppm of water vapor. In the AFM pictures, clear differences in damage are seen between the electrodes in the chambers with the freon mixed gas and the freonless gas; a combination of freon and water vapor caused the damage.

PACS: 29.40.Gx

The reason for the permanent efficiency drop in the GRPCs operated (in the streamer mode) with the chamber gas, contaminated with 1000 $\sim$ 2000 ppm of water vapor, has been studied since its finding during the development (1; 2; 3) of the Belle detector at KEKB. In this letter, we report Atomic Force Microscope (AFM) pictures of the surfaces of electrodes from the chambers that were used for the damage test that was previously reported (3). The samples were cut from the 2 mm thick glass electrodes. In the test, an efficiency drop was observed if the chambers were operated with a freon mixed gas ($Ar/C_4H_{10}/CH_2FCF_3 = 25/25/50$), but no significant drop was seen when using a freonless mixture (Ar/C_4H_{10}) with the same level of water contamination (1000 $\sim$ 2000 ppm) in the gas.

The AFM pictures of the glass surfaces are shown in Fig. 1. In the freon operated chamber, substances of 0.05 μm in diameter and 100 nm thickness are seen on the anode. On the cathode, larger diameter (0.08 μm) and irregular shaped substances are seen. We consider the substances as deposits on the glass based on these pictures. This explanation is also supported by the fact that the damaged electrodes can be recovered by scrubbing them using paper dipped in alcohol (2). In the freonless chamber, the observed substances are much smaller (0.005 μm), both on the anode and cathode.

In conclusion, the AFM picture clarified the scenario of GRPC damage; when glass RPCs are operated in the streamer mode in a chamber gas containing freon and operated under water vapor-contaminated conditions, deposits are formed on both the anode and the cathode surfaces. These substances reduce the work-function of the electrode surfaces, leading to the field emission of electrons from the cathode. This reduces the electric field inside the chamber below the efficiency plateau and causes a permanent efficiency drop.

Acknowledgments.

The authors thank Dr. C. Lu for suggesting us to examine the surfaces of the damaged glass surface by AFM. We also thank all of the members of the KLM subdetector group in the Belle collaboration for their many useful discussions and information about glass RPCs.

References

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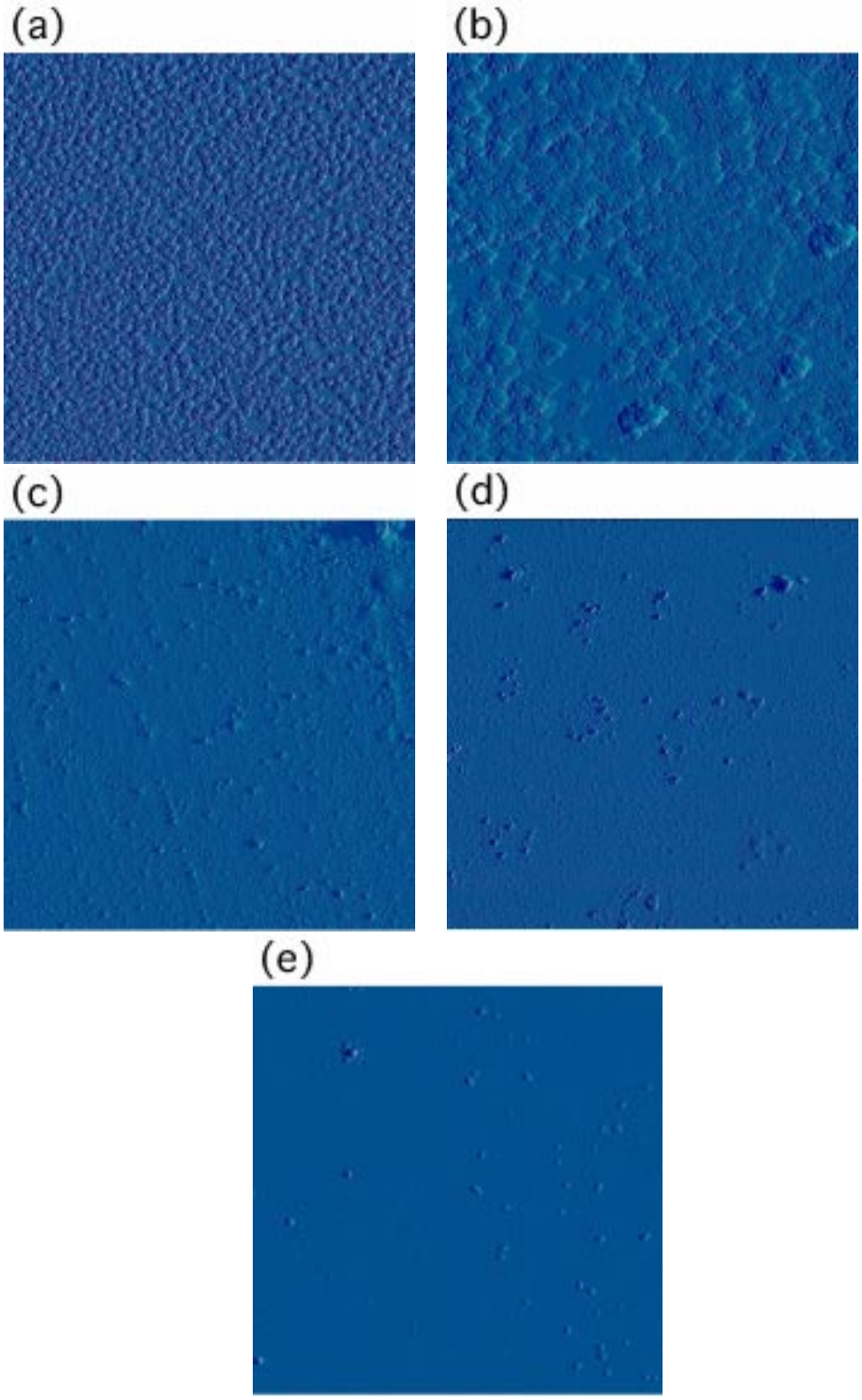

Figure 1: AFM pictures of glass surfaces. (a) anode (freon), (b) cathode (freon), (c) anode (freonless), (d) cathode (freonless), (e) brand new glass. The size of each frame is 10×10 μm.

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